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# Investigating Collaborative Development Activities in a Virtual World: An Activity Theory Perspective

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# Investigating Collaborative Development Activities in a Virtual World: An Activity Theory Perspective

*Completed Research Paper*

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## **Abstract**

*Contemporary virtual worlds provide unique environments in which users may collaborate in the development of shared digital artifacts. However, the ways in which such collaboration takes place is to date under researched. This paper uses an activity theory perspective to analyze the development activities of two communities within the virtual world of Second Life, based on data gathered using ethnographic methods. The study reveals (1) the complimentary and diverging practices utilized by these two different communities of practice, (2) the mediating function of various tools, rules, and work roles in collaborative development activities, (3) the tensions created in such activities and the manner in which users overcome these tensions.*

**Keywords:** Collaborative Development, Digital Goods, Virtual Communities of Practice, Virtual Ethnography, Virtual World, Second Life, Activity Theory,

## Introduction

Online collaborative activities by networks of users have been well documented to date, with many recent studies exploring the collaborative nature of what has been labeled the “Web 2.0” phenomenon (e.g. O’Reilly, 2007; Sheun, 2008; Beer and Burrows, 2007). While the term Web 2.0 is not seen to have a strict definition, it has been primarily characterized as a collection of technologies and techniques designed to facilitate collaboration and sharing between users (O’Reilly, 2005; Tredinnick, 2006). Researchers’ have examined an extensive array of related phenomena such as collaborative authorship, product/service co-creation, crowdsourcing, open source software, etc. (c.f. Benkler, 2006; O’Reilly, 2005; Kane and Fichman, 2009; Prahalad and Ramaswamy, 2004; Emigh and Herring, 2005; Brabham, 2008). Moving beyond the traditional web, Virtual Worlds (VWs) sometimes labeled “Web 3D” (Driver, 2008), have emerged as a new online context for community of practice and collaboration, evolving from earlier text-based multi-user environments (Bartle, 2003). Thus the internet has been increasingly understood as an expanding platform that enables diverse, interactive networks of users to share, communicate, and collaborate in order to develop content and goods; both digital and physical (cf. Tapscott and Williams, 2007).

Although the research community has not yet agreed upon a single definition for VWs, contemporary VWs are generally characterized as graphical, persistent, immersive environments which facilitate interaction among users and the development of user avatars and in-world objects (Davis et al., 2009; Franceschi et al., 2009; Eschenbrenner et al., 2008; Riordan et al., 2009). VWs take many forms, but the dominant “genres” include fantasy based hedonic systems (e.g. World of Warcraft) and ‘open cultural’ environments (e.g. Second Life) (Franceschi et al., 2009); the latter include elements reflective of utilitarian information systems, namely providing instrumental utility for users (Verhagen et al., 2009).

Research on VW’s has primarily explored application areas such as gaming (e.g. Craft, 2007; Moore et al., 2009; Meredith et al., 2009;), education (e.g. Warburton, 2009; Girvan and Savage, 2010; Eschenbrenner et al., 2008), marketing (e.g. Lehdonvirta, 2009) and business (e.g. Cagnina and Poian, 2009), with much of the research emerging from the Information Systems (IS) community focusing on one specific open cultural environment, Second Life (SL). Although SL is actively managed by Linden Labs, the users of SL are relatively free from constraints, and are able to develop unique technological and cultural artifacts as well as pursue a diverse array of creative and personal agendas (Fetscherin and Lattemann, 2008; Arakji and Lang, 2007). Within contemporary VWs the establishment, development and operation of communities are impacted by their additional spatial and graphical properties, in addition to the extensive functional capabilities, communications tools and social mechanisms (Riordan et al., 2009). Furthermore, the affordances of VWs such as self-expression, co-creation, co-experience and crowd sourcing have been acknowledged as enablers of attributes of communities of practice (Goel and Ives, 2009).

According to Wenger et al., (2002), “communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis” (p. 4). The concept has extended to the internet, in which online ‘virtual communities of practice’ have been recognized as comprising of constructs such as ‘mutual engagement’, ‘joint enterprise’, ‘shared repertoire’, ‘community’ as well as ‘learning or identity acquisition’ similar to traditional ‘face-to-face’ communities of practice (Murillo, 2008). In agreement with Nara et al. (2009), we utilize the above contemporary definition due to its ability to address both face-to-face and virtual, as well as organizational and open (not constrained by an organizational context) communities of practice.

A distinction exists between virtual communities that are spontaneously shaped by aggregating users with similar interests from those organized by specific organizations (herein referred to as virtual teams) (Li, 2004). However, both such collaborations are understood to be bound to various traditional characteristics such as team formation, task-technology fit, norm development, shared understanding, trust and leadership (Davis and Zigurs, 2009).

In recent years IS research has begun focusing on the e-commerce potential of VW’s relating to virtual goods (Hendaoui and Limayem, 2008). Guo and Barnes (2009) note the huge economic value of VW’s via selling, buying and trading of virtual goods. These are user generated digital artifacts that act as mechanisms for enabling self-expression, increased capability and utility as well as fostering relationships. Literature (e.g. MacInnes, 2006; Lehdonvirta, 2009) has made reference to various sorts of virtual goods such as furniture, clothes, art and real estate such as houses, shops, land, etc.

In addition, various perspectives on virtual economies and ‘real-money’ trade of virtual goods have emerged, such as economic (e.g. Castronova, 2001), business (Lehdonvirta, 2009) as well as legal (e.g. Fairfield, 2005). Fairfield

(2005) addresses property-like goods as ‘virtual property’, which may be governed under rights allocated to those who possess the intellectual property and subsequent rights via license agreements. The modeling, texturing and scripting development functionalities of VW’s like SL enable users to develop their own goods (Chase, 2008), the appearance of which may be classified as being realistic, semi-realistic as well as non-realistic with regards to design (Gu et al., 2009). There is of course, an enormous amount of non-realistic, fantasy based goods within SL. However, the interest in these environments for many has also seen the development of virtual goods that specifically portray a realistic/semi-realistic design. Girvan and Savage (2010) note the considerable amount of ‘real life’ learning experiences replicated through the development of lecture theaters in VW’s, emphasizing the need to move beyond replication and instead embrace the unique characteristics and potential that the technology may offer.

To date, numerous online communities of practice such as open source and crowdsourcing communities have been studied with regard to their development activities (e.g. Mockus et al., 2002; Brabham, 2008; Madey et al., 2002). Recent VW studies (e.g. Chase, 2008; Ehsani and Chase, 2009; Gu et al., 2009) have begun focusing on architectural and design aspects relating to the collaborative development of goods carried out by users. Such research reveals the dynamic nature of collaborative modes of operation; and suggests that a ‘one size fits all’ approach is not optimal for successful collaborative design (Ehsani and Chase, 2009). Collaboration in the development of shared artifacts (virtual goods) within SL has been acknowledged as a complicated task (Wadley and Ducheneaut, 2009). Various design software are also used to develop importable goods (Gu et al., 2009). Combined, these artifacts aid in mediating activity; their inclusion brings about a hybrid approach whereby collaboration and development activities carried about by communities of practice span the physical world, the traditional 2D web, the use of software applications as well as the VW.

The objective of this study is to conceptualize the collaborative development of virtual goods within VWs. Specifically, this paper presents insight into the culture of collaborative development activities within SL. Informed by our chosen conceptual lens, Activity Theory, our study attempts to address the above objective by answering the following research questions:

**Research Question 1:** How are collaborative development activities mediated in Virtual Worlds?

**Research Question 2:** How are tensions impacting collaborative development activities in Virtual Worlds overcome?

The paper begins with a discussion of the conceptual model (Activity Theory) and its applicability to collaborative activities as well as online environments. This is followed by a description of the data gathering (qualitative ethnographic data) and analysis methodology. Our analysis presents insight into the collaborative development activities of a virtual community (Studio Wikitecture development community) as well as a virtual team (University of Nottingham’s e-learning development team). Next we present the findings of the study, conceptualizing the mediated nature of collaborative development activities in SL, describing the sources of tension with these activities, and explaining how such tensions are overcome. We conclude the paper by discussing the study’s contribution to extant understanding of collaborative development in VWs, and the implications of our work for both research and practice.

## **Conceptual Model**

In this section we discuss Activity Theory (AT) as a conceptual lens for studying online collaborative development activities. We begin by outlining the value of AT as well as its appropriateness in studying virtual communities of practice. Next we discuss the theory in detail, outlining the interrelated components of the activity system model and the theory’s ability to highlight contradictions within goal directed activities.

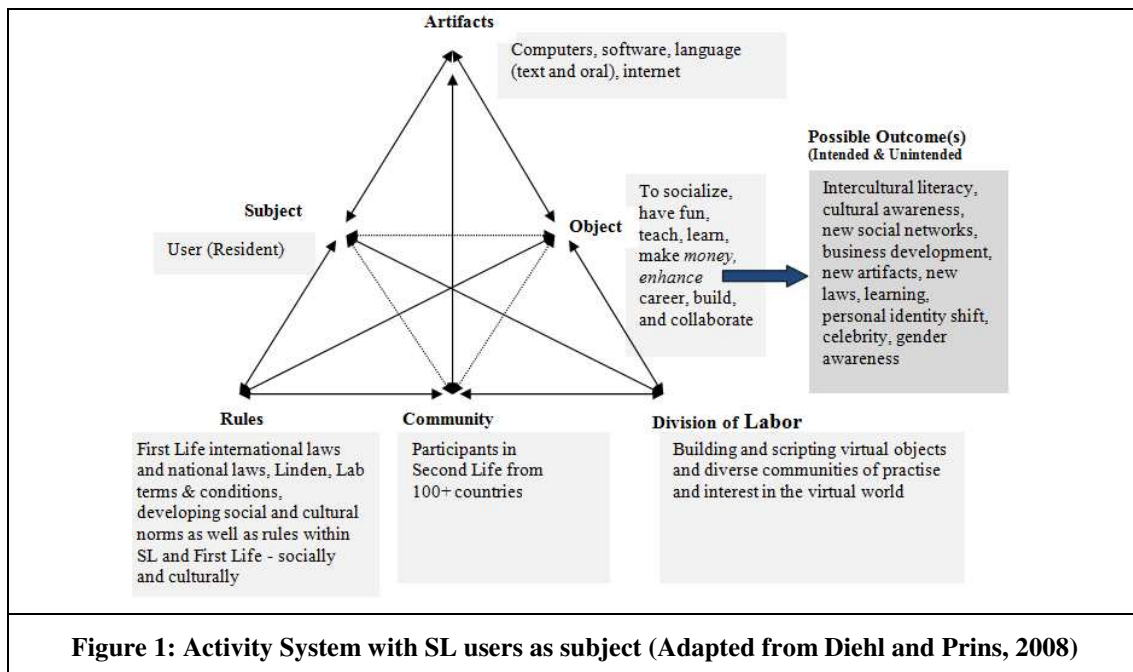
Theories such as AT, distributed cognition, situated action, and actor-network theory are considered prominent approaches for studying activity and action *in context* (Hemetsberger and Reinhardt, 2009). For instance, Barab et al. (2004) note that actor-network theory is useful for characterizing a system and providing insight into its functioning, however network approaches (such as AT) are useful for “observing the dynamic transactions of a system as a simultaneously functioning unit” (p. 210). AT is utilized in analyzing relations and tensions in goal-directed activities taking into account the societal and collaborative nature of actions (Engeström (1987). Uden and Damiani (2007) note that in adopting AT simple casual explanation of activity is avoided and instead the theory provides for a description of activity that is understood as an ensemble of multiple systematically interacting components.

AT and communities of practice are both strands of cultural-contextual theorizing which acknowledges the importance of mediational means (Engeström et al., 1999). Wenger (1998) has noted that AT and Communities of Practice share similarities as both are concerned with tensions and contradictions that exist between the collective and the individual. Suthers et al., (2006) highlight their interconnected nature in noting that “communities of practice are activity systems, and communities and their activity systems are nested” (p. 750).

Rooted in German philosophy as well as historical-cultural soviet psychology founded by Lev Vgostsky, Levont’ev and Luria, the formulation of the activity system model by Engeström (1987) set out to provide researchers with a theoretical model to explicate the components and internal relations of an activity system. The activity system is characterized as being an “object oriented, collective, and culturally mediated human activity” (Engeström, 1999, p. 9). Kuutti (1996) argues that regardless of its roots, AT is multidisciplinary in its nature, given the acknowledgment that activities are meaningful objects of study in which human qualities must be taken into account, and that activities as a whole cannot be studied exhaustively by any one discipline.

AT has been applied to research in the fields of Human-Computer Interaction, Computer Supported Cooperative Work, IS and Information Science (e.g. Barthelmess and Anderson, 2002; Bjørke, 2004; Mwanza 2001; Benson et al., 2008; Wilson 2006). More specifically, it has been applied to collaborative development within virtual communities of practice such as open source software projects (e.g. Hemetsberger and Reinhardt, 2009) and to activity within VWs (e.g. Zager, 2002; Diehl and Prins, 2008). Murphy and Rodriguez-Manzanares (2008) paper analyzes various educational technology studies that have used AT as a conceptual lens. Here the authors highlight the theories ability to provide insight into contradictions and transformations that occur in using information communication technology for educational use. For instance, Brine and Franken (2006) use of AT in studying challenges within online educational environments for group processes and subsequently how new tools impacted these processes. Hemetsberger and Reinhardt (2009) use AT in studying how problems of dispersed work as well as inherent contradictions are overcome within an open source community. Their use of AT also highlighted various enables (activities and artifacts) for collaboration within the community.

As our conceptual lens, we employ an Engeströmian activity system to represent VW activities (see Figure 1), adapted from Diehl and Prins (2008). The model represents activity in the VW as being mediated by various rules, tools and labor division and that achievement of objects may result in various possible outcomes (both intended and unintended). Mediation, as understood within AT, stipulates that the subject-object relationship is not direct but instead is enabled and affected by rules, roles and artifacts.



The above model includes seven central interconnected components. The *subject* refers to the actor(s) (individuals or sub-groups) involved in the activity whose viewpoint is adopted, in this case, SL users. *Artifacts* are the tools, instruments, procedures, machines, signs, and methods used in order to accomplish, understand, motivate, or envision a potential future state of the activity systems object. Within AT, internal/mental activities (e.g. mental simulations, plans, imaginings, etc) of people are materialized into artifacts (instrumental and semiotic) via exteriorization of internal activities into external ones (c.f. Leont'ev, 1978). The *object* coordinates members working in disparate functions by providing a context beyond that of an individual subject (Zager, 2002). The *community* component refers to the collection of participants of an activity system, who share the same object e.g. an organizational/institutional team or grassroots community. In addition, there are explicit and implicit governing *rules* and norms within an activity system as well as the *division of labor*, such as tasks, roles and responsibilities among members of the community. Finally, various *outcome(s)* such as processes and products of the activity may come about as a result of activities. The transformation of the object into outcomes also is understood to motivate the existence of an activity itself.

Furthermore, AT brings with it the acknowledgement that contradictions/tensions exist within the social/mental relations among groups of subjects and their mediating artifacts. These are described as disruptions, (Berge and Fjuk, 2006), conflicts (Dippe, 2006), problems, ruptures, breakdowns, and clashes in activities (Kuutti, 1996). They may refer to the interruption of work by something; such as the unanticipated behavior of a tool, impacting operations as well as a change of focus or object with regards to actions of activity. However, AT interprets such tensions as a source of development (Uden and Damiani, 2007) if their resolutions occur at the societal level (Murphy and Rodriguez-Manzanares, 2008). Acknowledging that tensions exist, this study aims to identify the way in which they are solved and consequently how activities are mitigated.

## **Research Method**

Little is known about collaborative development activities in VWs beyond descriptive and narrative accounts of activities and functionalities with a limited number of empirical studies focusing primarily on design related issues. In addition, prior research on virtual goods has been preoccupied with their economic disposition or their marketing potential, rather than details relating to development processes.

To address this gap, the objective of this study is to understand the manner in which the collaborative development of virtual goods takes place within Virtual Worlds. Guided by the theoretical model previously described, this objective is operationalized through two research questions (presented in the introduction section).

SL was deemed suitable for this study due to its strong support for developmental activity, its “open” culture, and its high levels of observable collaborative development. Ethnographic methods were employed as a means of gathering data. The decision to adopt an ethnographic approach was based on the fact that the phenomenon under investigation is recognized as computer mediated interaction, and thus suited to (virtual) ethnographic investigation, similar approaches have been utilized in studying VWs (e.g. Boellstroff, 2008; Bardzell and Odom, 2008; Irani et al, 2008). In addition, AT provides a descriptive language noted for its ‘ethnographic-like emphasis’ that is complementary with descriptive unites of analysis such as communities of practice (Dobson et al, 2004).

Murthy (2008) declares that as ethnography goes ‘digital’, its epistemological concern remains much the same. Virtual ethnographic methods may be acknowledged as qualitative research methods that require the adoption of traditional features of ethnographic research (Kozinet, 2002). As such, data collection methods included: Semi-structured interviews, documentation analysis, observations, avatar-shadowing (encompasses the visual tracking of avatars movements and actions) and instances of participation observation.

Data collection was carried out during the months of February-July, 2009. A SL account was created for research purposes, with the user’s public profile detailing the nature of the study. Chat logs for approximately 150 public and private synchronous and asynchronous discussions between users and groups over this period were recorded and around 80 field note entries comprising of over 250 pages of data were created relating to observations, interviews and other data gathering activities. Appropriate informants were identified using a chaining process. Interviews were initially conducted with key informants identified through the participant observation process, and additional informants were identified through these interviews. The data was collected from two collaborative development groups within SL, one constituting an informal virtual community, the other a formal virtual team.

First, the SL Studio Wikitecture community was identified as a data collection site, in which members collaboratively acted as designers and developers in the context of group projects. The community's charter explicitly outlined its aim of "testing procedures and protocols necessary to harness the 'Wisdom of Crowds' in designing architecture" within SL. Thus, it was deemed a suitable site for studying collaborative development. Analysis of the Studio Wikitecture Community begun in March 2009 at which time the community consisted of over 250 members, however the vast majority of these users appeared to be inactive as developers within the community during this time.

During initial analysis, the community was between development projects, however, the groups profile information provided a list of members from which the researcher was able to contact the group organizers. Provided with links to the communities website/form, wiki blog and group development 'site' within SL the researcher was able to uncover the users who participated in the communities latest development projects. These users were contacted and over time describe features of their culture or social system within the studio wikitecture community via e-mail, IM and avatar-avatar communication (text and VoIP). As analysis continued, the researcher followed up discussions with users in order to clarify their perceptions of various issues and tensions mentioned – such as permission rights. In June 2009, the community participated in a short-term development project celebrating SL's sixth anniversary. During this time, observations and discussions with a selection of active users both within SL and on the community forum validated insights gained by earlier documentation analysis. Here the researcher was able to observe several users perform development tasks. The researchers' participation within the community's development projected included reviewing and voting upon design contributions submitted by members. In addition, the findings were presented to the group's organizers motivating further discussions as to their personal perceptions of the Studio Wikitecture activity system objective.

Second, as the reviewed literature focused heavily on collaboration within an educational context, the ethnographer began searching for signs of development teams amongst various educational sites within SL. Analysis of the University of Nottingham (UoN) development team begun in April 2009, at which stage the team had already begun development of a virtual 'web campus'. Primarily, three team members (UoN employees) were observed developing the campus on a part time basis with several other faculty members contributing on the periphery with regards to actual development activity. The team engaged in regular development activity; as a result, over 150 visits to the campus were carried out during this time, whereby regular instances of avatar-shadowing and interviews with the development team took place. Various 'pictures' of the development site were also captured, visually recording development progress. In July, the ethnographer took part in a 'micro' development project with a UoN member, designing and developing a 'prop' object. This instance of participation observation aided in confirming the complexities with regards to collectively developing individual goods.

Prior to and during the data collection period, time was taken to overcome the various learning challenges of operating within SL, specifically developing, collaborating and sharing goods in addition to learning the cultural terminology employed by users. The SL Forum, Wiki and tutorial videos were utilized in conjunction with participation in several tutorials hosted by community groups within SL. Collectively, these proved crucial in gaining insight into the main issues associated with development and collaborative development amongst user groups.

### ***Data Analysis***

Throughout the field study, the ethnographer pursued a cyclical repetitive pattern of (1) enquiry/observation, (2) data collection, (3) recording of field notes and (4) analyzing data in relation to activity system components. Interviewees Field notes items were rewritten in the context of activity system components, and tagged. Mwanza's (2002) eight-step model incorporated within the Activity-Oriented Design method was utilized as a requirements capture methodology for the study, operationalizing the activity triangle model. The approach is acknowledged to help provide contextualization of an activity system and has been utilized in other such studies employing the use of AT (e.g. Benson et al., 2008; Mwanza and Engeström, 2005).

Discussions with users and documentation analysis of members past activity highlighted various mediating components relating to the collaborative development of goods as activity systems. These were verified via subsequent revisits to locations, observations and/or analysis of information provided by users through discussions with SL developers, public and group IM's, as well as review of user content on the SL forum and SL Wiki. In addition, numerous native terminologies and interpretations of actions were translated to provide a more culturally

neutral account of activity as well as associated mediators and tensions. Tensions experienced by users were further validated through the ethnographer’s own experimentation in developing goods within SL, both individually and collaboratively. Preceding the data collection phase of the study, the large repository of qualitative data was further reviewed in identifying contrasts and comparisons between the long term and short term mediating activity as well as tensions within the two cases observed. Having identified various tensions, the collected data was revisited once again, clarifying the manner in which users overcame these issues.

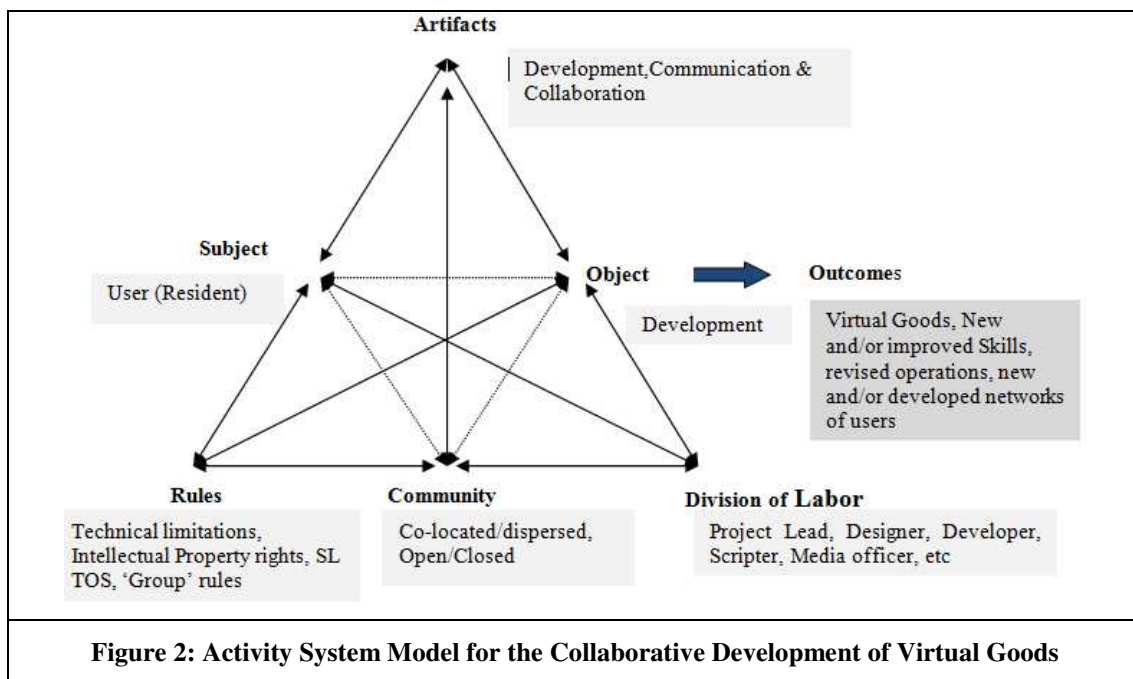
## Findings

This section presents the findings of our study, beginning with an outline of collaborative development activities within SL, highlighting the mediating activity system components. The section progresses with an in-depth analysis of two case examples, comparing their mediating nature before discussing the various tensions acknowledged to impact user collaboration and development activities. Following this, the section continues by presenting and discussing user and provider initiated solutions used in overcoming a number of these tensions.

### The Mediated Nature of Collaborative Development Activities

Within SL, users have the ability to collaborate on a user-to-user basis (between ‘friends’) or within larger explicitly created collaborative bodies (known as ‘groups’). In addition to in-world mediation, such activities may be heavily sustained through mediation outside of the VW, including traditional collaborative and development software and applications or instances of physical world interaction between collaborating members. Our analysis suggests that collaborators are typically unassisted by others during the actual development of individual goods, taking a form of “passive collaboration” in which users tend to focus on individual tasks within a development project, interacting synchronously and asynchronously with one another within a shared location in SL. The design and modeling of goods such as ‘buildings’ are also mediated through processes of trial and error as members build upon and modify goods, which on occasion are aided through artifacts such as ‘scripts’ and ‘textures’ provided by other members.

Figure 2 presents an activity system model specifically detailing high-level components of development activity. Although collaborative development activities involving the design and construction of virtual goods within SL are mediated in ways that are unique from one collaborative body to the next, the model serves to capture the generic shared characteristics of the collaborative development activities observed.





The development, communication and collaboration *artifacts* outlined encompass the wide range of mediating tools, many of which are provided by the SL viewer (the actual SL “application” run by the user) such as modeling, texturing and scripting tools, messaging and chat tools, avatar gesturing, group and sharing managers, etc. However, as noted, these may also include traditional web resources such as forums as well as physical world artifacts such as face-to-face discussions and offline design sketches. Furthermore, media editing software as well as 3D modeling software are also artifacts used in the development of goods. In addition, certain traditions take place within activities through the assignment and self-assignment of *roles* within SL such as ‘builder’ and ‘scripter’. These roles are sometimes explicitly outlined, other times they are implicitly undertaken by collaborating users in various ways with some users undertaking multiple roles.

*Rules* encompass the governing technical restrictions of the environment such as limitations to the number of objects and avatars in a given area (scaling collaboration and development) in addition to social norms and guidelines common to the VW or idiosyncratic to a given team/community of users. Explicit collaboration on the design and construction of goods between users is enabled through the provision of certain permission settings (governing IP rights) inherent to all SL goods. Permission sets act as rules governing the manner in which users achieve their objective by restricting the abilities in which goods can be accessed and shared between members. Table 1 presents three modes in which the accessibility of goods can be set, enabling or inhibiting degrees of possible collaboration.

Table 1: Permissiveness of Goods	
Permissions	Description
Fully-Permissive	The good(s) can be modified, copied, transferred from user to user
Partially-Permissive	e.g. No-Modify, No-Copy, but can be transferred from user to user
Non-Permissive	The good(s) cannot be modified, copied, or transferred

### Mediating Effects

Our analysis revealed both commonalities and significant differences between the mediation of collaborative development activities in the two cases observed. Table 2 summarizes these similarities and differences. The distinctive characteristics of the ‘community’ component of an activity system were revealed to be critical in the adoption of certain mediating artifacts, rules and labor division enabling and sustaining unique instances of collaborative development activities.

The group tool (used in both cases) mediated collaboration by enabling the creation of explicit, purposefully driven organizational bodies with customizable access properties relating to entry into the group and capabilities of users. These include but are not limited to group messaging and notices as well as member resource sharing functionalities (e.g. the ability to relinquish ownership of objects to a group (‘deed’) group as well as access and modify group owned goods).

As the UoN team was physically co-located outside of SL, greater reliance was made on direct (physical world) communication (with project managers, academic staff, etc) and less on communication within the VW. Face-to-face discussions, meetings and presentations amongst members are all artifacts embedded in the physical world; as such there is less dependency on the VW to provide collaborative communication functionality such as instant messaging or voice over internet protocol (VoIP). Furthermore, collaboration was somewhat ‘passive’ as members generally tended to operate individually during development, regularly undertaking separate development projects.

Alternatively, the Studio Wikitecture community is acknowledged as pursuing a highly collaborative approach in which a diverse group of innovative users with shared interest create value via the design and development of architectural projects. While collaborative activity in this instance does not take place within the context of the physical world, the traditional web and VW are more heavily relied upon for sustaining communication – such as occasional avatar-to-avatar meetings, group notices as well as the use of blogs and forums.

Both development activities were governed by the use of virtual ‘land’ within SL. Land (*artifact*) provides collaborators with a unique location in which avatars may synchronously communicate and develop goods. Through

the zoning/segmentation of land (known as ‘parceling’), developers are capable of limiting the parameters of development projects. Furthermore, land settings enable the creation of customizable settings within a given location, allowing users to enforce rules banning, immobilizing and limiting the accessibility and development capabilities of avatars and groups of users.

In addition, the associations and functions of goods developed are mediated between collaborators through shared cognitive understandings of the signs and symbols inherent of their visual designs. For instance, the UoN web campus has myriad examples of goods acting as signs and symbols communicating to both developers and users. For instance, pathways are constructed leading from one area to another, fences and sloped landscaping as well as water features separate individual project areas. Posters, banners and signposts publicize the university by means of displaying the university logo; a red British post-box and telephone booth developed by the team symbolize the connection the campus has to the United Kingdom, while the architectural features of the Trent Building developed by the team on the web campus communicates its connection to Nottingham. Furthermore, “Under construction” signs were used to signal projects that were incomplete while the props developed in the virtual pharmacy labs contained interactive representations of instruments used by pharmacy students in the physical world.

<b>Activity of interest</b>	UoN E-learning Team	Studio Wikitecture Community
<b>Object or Objective of activity</b>	Web Campus encompassing the development of various projects	Architectural crowdsourcing Projects
<b>Subjects in this activity</b>	UoN Staff	SL Studio Wikitecture members
<b>Tools mediating the activity</b>	SL client viewer and Grid Group Tool Virtual Land Linden Dollars Face-to-face discussions External software applications Web media	SL client viewer and Grid Group Tool Virtual Land Linden Dollars Community Website and forum External software applications User created ‘Wiki-tree’ tool Web media
<b>Rules and regulations mediating the activity</b>	SL terms and Conditions UoN Staff rules and Regulations Group rules and norms Virtual Land Settings Permission Settings	SL terms and Conditions Group rules and norms Virtual Land Settings Permission Settings
<b>Division of labor mediating the activity</b>	Work was divided primarily amongst 3 team members, managed by a team leader.	Members contributed as desired, with activity organized by the community leader
<b>Community in which activity is conducted</b>	Private team of co-located employees	Open community of geographically dispersed SL users
<b>Outcome</b>	Development of a web campus containing various project ‘sites’ for use by staff and students	Development of collaboratively designed artifacts/virtual goods

In both cases, activities were mediated via forms of hierarchical management (leadership), with the presence of an overseer. Due to the dispersed and voluntary nature of the Studio Wikitecture community, activity was sustained by the use of explicit activity phases/stages, presenting various deadlines to members (e.g. preliminary, intermediate

and final Design stages), incorporating voting and discussions between members. Also, the skills required by members in both cases were highly diverse – e.g. scripting, media development, 3D modeling, design, management, etc – with users’ capabilities, interests and contributions varying dramatically from user to user. As one member of the Studio Wikitexture community explains, in reference to the design of a virtual classroom, *"My own contribution focused on interactive features meant to simplify some activities (i.e., distributing handouts and URL selection). Several elements from my interactive classroom were included in the final design"*.

Finally, observations witnessed member activity and inactivity over lengthy periods of time. Within the Studio Wikitexture community, user participation saw periods of activity and dormancy in between design stages and projects. Here the community was seen to periodically manifest as an active collaborative body of developers when a project or deadline was presented to the group. To a lesser extent, internal requirements dictated the need of UoN teams’ members to become active in development for specific department projects. As such, development activities were seen to be highly dispersed throughout lengthy time periods, with some of the projects spanning months in development as well as months apart, resulting in a relatively dormant stage of development activity, while other projects within the virtual campus were in periodic development for over a year.

### Sources of Tension

To effectively engage in collaborative development, both individuals and groups must overcome a variety of tensions (as previously defined) that are inherent in the activity systems studied. These can range from technical limitations on the number of avatars, objects and scripts that can co-exist in a given area within SL before resulting in degraded user experience (e.g. lag), to the sheer complexities of learning how to navigate and develop goods virtually. Such tensions, however, go beyond the steep learning curve and technical limitations of SL. Our analysis revealed additional sources of tension related to the management of goods and collaboration between users.

First, users depend on the availability of the SL grid to manage goods, collaboratively or otherwise - with this comes certain unavoidable tensions. For instance, during the data collection period, over 80 planned outages of the SL grid occurred with frequent additional unplanned issues occurring throughout the grid on various occasions. Issues encountered by users during such disruptions range from delays in deploying objects within SL (‘rezzing’), the inability for users to ‘teleport’ from location to location or attach items to avatars, to enter regions, to use group chat functionality, process payments, maintain user inventories, etc.

Second, the development of goods within SL is subject to the terms and conditions as set out by Linden Labs. These terms and conditions state that users hold the Intellectual property (IP) and copyrights of goods developed. However, Linden Labs retains ownership of users’ accounts and their related data, all of which resides on the servers of Linden Labs and is subject to “deletion, alteration or transfer”.

Third, developing goods within SL may incur certain costs for users. For instance, each texture, sound and gesture upload incurs a micro-fee of \$L10. Given the level of detail applied to goods, these costs may accumulate causing tensions for some users. Adding to this, development activities such as those observed in the two field sites require the use of virtual land, with private regions costing in excess of several thousand \$US to run per year (plus the additional cost of the land owner needing to have a premium SL user account).

Fourth- and specifically impacting user collaboration, the mismanagement of the permission sets inherent within all user created goods can explicitly cripple an objects capability of being modified by other users indefinitely, as indicated in Table 1. Confusion with regards to the permission rights of goods exchanged between SL users was observed to be a common problem by many, especially novice users. While permission settings are not overly complex in themselves, the manner in which members collaborate, create and share goods may bring about complicated scenarios. As a UoN developer explains, with regards to the self-governing and sharing of goods during development, *"When we are working on projects in Second Life we tend to split the work up so the design and build of objects is done separately to adding any scripting and functionality. Although this tends to work well it can sometimes cause problems as object permissions in Second Life are confusing and not ideal... Setting permissions becomes particularly time-consuming and confusing when an object contains other objects which also contain objects and scripts...on occasion you can end up with items that no one is able to edit, even the original creator of the item... [Therefore] it's important for us all to keep copies of each item even after it has been passed to a colleague"*

As noted above, users observed often retain copies of their goods in inventories that reside in individual user accounts, rather than in a potential group inventory storage system accessible to all members of a team/community. In addition, the sharing methods within SL enabling access to goods between users and groups of users bring with them certain drawbacks (See Table 3).

<b>Table 3: Sharing Methods</b>	
<b>Method</b>	<b>Drawback</b>
<b>Enabling Movement</b>	No control over who moves your object or where they move it to Objects must be individually set to allow for this method
<b>Enabling Group Access</b>	Group members can delete your objects All content inside the object must be set to “share with group” in order to be accessible to others
<b>Deeding to a Group</b>	The transferor loses control of the object transferred
<b>Enabling Access to Friends</b>	Friends can freely modify/ delete your objects and their contents
<b>Transferring Ownership</b>	The transferor loses control of the object transferred

### Overcoming Tensions

This section highlights artifacts observed to aid users in overcoming tensions impacting both collaboration and development activities. These relate to the process of learning and revision of user operations over time; the sharing of accounts and inventories; the development and use of user created tools; interaction and support from the SL community, in addition to the constant evolution of the technological infrastructure of SL supporting these activities.

### Learning and revised operations

Learning has been acknowledged as an intricate part of the mediating nature of collaborative activities and has been commonly observed and studied in previous activity theory research (e.g. Murphy and Rodriguez-Manzanares, 2008; Mwanza and Engeström, 2003). One manner in which learning may be acknowledged to impact collaborative development activities in SL is when it occurs as users identify and undertake solutions with regards to overcoming tensions that arise within development activities. Such learning may give way to certain ‘best practices’ amongst users and mitigate the initial complex development work into easily understood tasks.

For example, after the initial outcome of constructing the virtual Trent building, the UoN team explicitly acknowledged certain design issues; specifically, a technological issue that results in users experiencing lag within locations of high object counts within the virtual world. As a result of this outcome, the ‘building’ was completely reconstructed (in less time than its initial construction) with the additional constraint of a perceived design/development rule of being *prim efficient* (Conserving the number of objects used in the development of a good) which in turn brought about revised operational practices, leading to the redevelopment of the Trent building using approximately a third less objects in its construction. As for the Studio Wikitecture community, all goods underwent various design stages as members voted upon design contributions leading to an eventual final product. These goods were created as a result of various trial and error development contributions and modifications by users.

These examples suggest the emergence of ‘adjustable exploitation learning’, which is understood as being the ongoing acquisition and internalization of existing knowledge and skills within the given activity. In addition, the completion of the development activities comes as a result of incremental exploratory learning (learning through experimentation) by members. What can be observed from the UoN example above is that within this particular instance of learning and knowledge building, preceding activities were impacted. In response to the technical issues surrounding high object counts, the development rule of being “*prim efficient*” become implicitly present in development activities throughout the campus; adding its mark to the cultural historical development of the overall activity system (development of the campus). In all, such learning may be acknowledged as radical exploration or expansive learning (c.f. Engeström, 2004).

## **Community Interaction and Support**

Learning by practice and learning within the gift-culture of the SL community are seen as part of users' progression from amateur to expert. A distinctive feature in the collaborative development of goods in SL is the notion of real-time, extensive community support that exists both within the VW and the traditional web, operating beyond the confines of a particular community or team. Users operate within the realms of a largely interactive, dispersed, knowledgeable community of users that can provide support and resources such as contributors (as is the case within the Studio Wikitecture community) as well as development and learning artifacts to any development activity.

Myriad web resources, such as wikis, forums, mailing lists and blogs are accessible to users via the traditional web providing textual information as well as tutorial videos. This in itself is nothing new as the web has often served as a knowledge repository for developers. However, such community support bleeds into the immersive virtual world, which provides its own forums of community resources and support. Publicly accessible groups hold daily development ("building", "scripting", etc) tutorials/classes, similar to co-learning experiences in the physical world. In addition, various other groups specifically aimed at building, scripting, sharing goods, etc., operate in which users interact via group instant messaging allowing users to chat, post queries, and freely obtain knowledge in real-time from more experienced developers.

Our analysis allows us to characterize SL as a living repository of active laborers, goods and knowledge that can provide extensive support, mediating development activities. Existing resources thus expand beyond the confines of those owned by a particular team or community to that of the resources provided by the collective co-existence of SL users and their resources, which continue to grow on a daily basis. This interaction from other users outside of one's own development environment is to be expected; be it through the use of community forums, interaction with markets, or avatar-to avatar interaction. Such user-to-community virtual interaction is almost inescapable at some point or another within SL. These may be understood as the impacting 'Community Support' and 'Community interaction' elements attributed to of development activities within SL.

For instance, the publically accessible Studio Wikitecture community collaboratively developed a "virtual class room" artifact for the University of Alabama to use in mediating e-learning activities for its students. The University of Alabama's own activity of developing a virtual campus is thus explicitly connected with the Studio Wikitecture activity of developing the virtual class room artifact for the campus, as students and staff contributed to its design. Similarly, the pharmacy module developed by the UoN team was copied and reproduced for use within the Pharamtopia community within Second Life. These interactions between systems of development activity by various groups of users are understood to develop resource networks for collaborators.

## **Sharing of Accounts and Inventories**

Within the UoN development team the researcher discovered the use of account sharing between members on occasion. When compared to the Studio Wikitecture community's practice of sharing virtual goods via opening up accessibility permissions, we are presented with the two extremities of sharing goods within VW collaborative development activities.

Essentially, the avatar, which represents the user (individual), is acknowledged as a 'personal' tool that users utilize to accomplish their actions-activities. Typically avatars are not shared amongst users as an avatars account contains its own inventory of goods, monetary funds, private information, as well as responsibilities (management/ownership of groups, land, etc). Instead, practices of sharing goods between members generally related to the electronic transferring of goods between user-accounts as well as sharing via enabling goods to be fully permissive as discussed earlier.

However, as a result of sharing accounts UoN members were able to overcome many issues relating to object ownership and accessibility simply by logging into the environment through another members account and accessing inventory resources belonging to other members. While clearly not a practical practice for an open dispersed group of users, the sharing of accounts can be acknowledged as an effective use of resources within a multi-user (account) development activity such as a virtual team. From a research perspective, this adds complexity in identifying the person 'behind' the avatar. Here the avatar extends its use as a personal tool in becoming a central shared mediator between subjects and their object(ive). From a development viewpoint, this capability was seen to speed up the development process on occasion, as users did not require the assistance of other members in order to complete shared development tasks.

In addition, the UoN team was observed to utilize an alternative shared SL account (referred to as an alt) between each other, enabling one account to ‘manage’ the development site (island). As one member explained upon enquiry, “we can all inhabit [it], presently it is [the lead scripter]... it provides more land permissions, the ability to rez linden trees, [and] change parcel permissions. It is the land administrator, with all permissions except ownership”. In utilizing this practice the shared user account (tool) facilitates the transformation of users and their roles (e.g. from scripter to project administrator) and responsibilities (e.g. from designer of goods to manager of land and parcel permissions) throughout the project, when required; bringing with it a sense of flexibility and convenience for users and their work activities.

### User Created Tools

Users are capable of creating goods that can act as tools, further enabling collaboration and development amongst members. The need for the development and use of user created tools by users highlight the limitations of SL in providing basic design collaborative tools for development activities, but equally they provide examples that highlight the innovative and creative nature of VW communities and teams. Figure 3 displays two examples of such tools. The first image is take from observations of the UoN web campus, the second image was captures a Studio Wikitecture development site.

For instance, using textured objects as a blueprint tool, two UoN members were capable of visually separating the design layout and construction of a ‘virtual building’ as seen below in Figure 3 (left). The design plans acted as a communication and design tool providing a shared understanding to both users as to the size and layout of the development; facilitating the users in its construction. Within the Studio Wikitecture community, the management and accessibility of user contributions is opened up via the use of the Wiki-tree object as displayed below (right). This is a user created prototyping tool that provides a virtual branch structure layout of design phases, visually representing user design contributions in a modifiable form. This innovative tool enables a tiered approach to development, enabling members to create and submit contributions to a design project as well as to vote on design contributions. In essence, this acts as an accessible group inventory (a feature unavailable to SL users in general) and a voting station for a given design and development project – making this a unique and highly creative approach for VW community design and development activities.

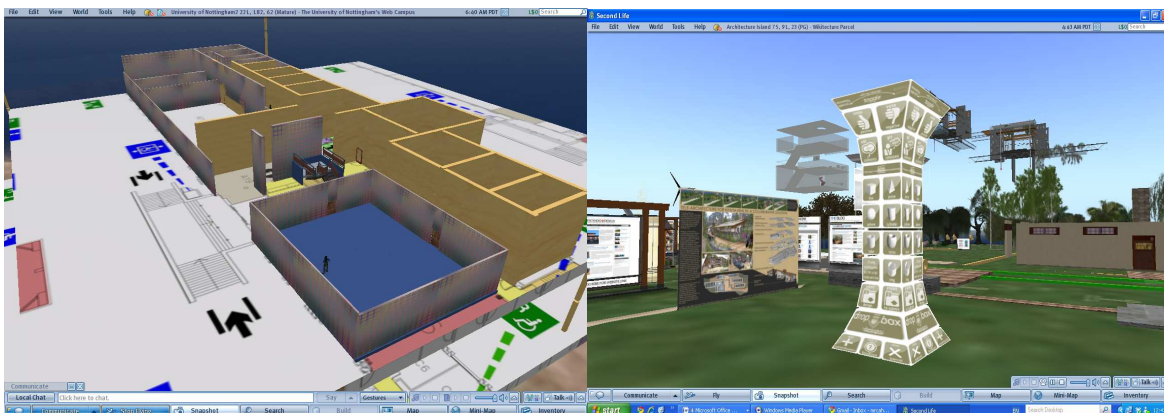


Figure 3: User Created Tools enabling deeper collaboration and development

### Changes to the Environment

The services and capabilities of SL for users collaborating and developing goods have constantly evolved. The resolution of tensions brought about by changes to SL is initiated by Linden Labs, unlike the previous user initiated resolutions of learning, creating tools and community support. However, these changes are brought about in reaction to user needs/desires in relation to the manner in which they engage both collaboration and development. Since its release in 2002 SL has continued to add functionality to user tools such as the inclusion of group options, developments to the scripting language to include HTTP streaming, XML-RPC, e-mail functionality, as well as

various interface updates, etc. The original 'Alpha' version did not facilitate the concept of ownership or IP rights of goods; version 1.09.1 saw the introduction of more complex design and increased XML-PRC functionality.

During the data collection period of this study, similar environmental changes occurred that impacted the operational practices of developers – expanding user's capabilities. For instance, additions to the scripting engine enabled the use of 'mono', an open source scripting engine (allowing for increased memory management, security, speed and flexibility with regards to scripting), as well as a new "bulk permissions" tool. The Bulk permissions option allows users to upload numerous images; sounds and animations in bulk with preset permission sets, mitigating for some the labor involved in customizing permission settings of goods. Before the introduction of this feature, each item uploaded in SL had to be individually set with regards to its permission sets.

## **Discussion**

The design and purpose of virtual goods and the collaborative nature of their creators act as highly transparent ways in creating and augmenting the 'real world' cultures of people in a digital, immersive, persistent, interactive and visual context. Rooted in the development of myriad virtual goods within both cases observed were elements of virtualization of infrastructures 'ferried' from analogue artifacts e.g. buildings, floors, walls, chairs, doorways, paths, tables, windows, logos, etc. These easily recognizable cues were observed to act as signs and symbols mediating the association, function and expectation of goods between developers. The use of these analogies 'glued' collaborating developers in their approach to developing goods. Here user collaboration and expression of cultural artifacts bare no boundaries imposed by the limitations of physical reality, allowing innovative and creative groups of people to visually share, develop and collaborate on various aspects of human culture – virtually.

While SL does offer a rich range of features for virtual collaboration (Kahai et al., 2007), these activities are sustained by interaction, collaboration and development outside of the environment, mediated through pure virtual, hybrid and face to face activity as seen within traditional forms of collaboration (Fiol and O'Connor, 2005). As such analysis of activity within SL covers only in part the totally mediation of VW communities of practice. These are prominent external tools used in VW activities and are part of their day-to-day constitution, and should be viewed as such – the VW does not operate in isolation of traditional web tools, instead they are undoubtedly intertwined.

Building upon Kohler et al., (2007) examination of 'avatar-based innovation' the development projects carried out by the Studio Wikitecture community can be seen as an effort to enrich the development process of real world innovation as some of their projects to date have focused on design projects related to the physical world. In contrast to acts of co-creation between companies and users however, this particular case acknowledges how creative and ambitious users can also reach out to solve real world problems of interest on their own initiative.

Technical progress facilitating collaborative work within Second Life is occurring – albeit slowly. Oliver and Pinkwartz (2007) paper on collaborative work in SL noted that at the time SL was not suitable for sharing non-SL artifacts such as text documents for joint work. The functionalities of the recent viewer 2.0 have made such collaborative tasks a reality enabling multiple users to edit documents in-world. The wiki-tree highlighted in this study also highlights a step towards enabling asynchronous structured communication (voting and commenting) as well as storage and management of VW artifacts all of which are integrated with the community's website. What is significant with regards to the development of interactive artifacts such as the wiki-tree tool is the capability of inventing usable hybrid analogues, blending physical world cues (a tree) with usable forms of digital collaboration (a wiki).

The Studio Wikitecture approach to development is understood to be unique given its prototyping of 'crowd sourcing' mentality in an immersive environment. The community may well prove to be an example of a potential outlier in way of its ability to enable and sustain highly collaborative development activities between users; resulting in the creation of peer reviewed and refined digital, 3D, interactive artifacts. In disagreement with existing literature (e.g. Chase, 2008; Chase et al, 2008; Ehsan and Chase, 2009), the Studio Wikitectures development activities are clearly not 'open source' in design. They are however highly innovative and creative approaches to organized collaboration in the design and construction of artifacts, open to the general public. Noted however, is the fact that the Wiki-tree software has become freely accessible under the Berkeley Software Distribution license – this may encourage similar style collaboration communities in the future.

Finally, we note the 'silence within collaboration', the work done individually and asynchronously by participating member at one time or another, each with their own internal preferences, interests and meanings, unspoken and as of

yet unrecognized. What tools or rules can we use or create within immersive systems that generate, share and utilize this knowledge to enable ‘smoother’ collaboration amongst teams and communities? And how can users be motivated to share their individual experience in a useful and productive manner, before, during and after their collaborative development activities? Finally, will the answers to these questions be user created or provided by the system, such as deeper web integration within the VW?

## **Conclusion**

This study has presented insight into the mediated nature of collaborative development activities within Virtual Worlds. Our analysis highlighted tensions associated with collaborative development, and the mediating tools, rules and roles that enable users to overcome these tensions. Our work has implications for researchers and users of VWs, and improves understanding of collaborative development activities in such environments.

First, our study shows that the complexities associated with user collaboration and the development of virtual goods within VWs can be mitigated by the social nature of the environment (unlike standalone open source versions of the SL platform that exist isolated behind an organizations firewall). If a development project’s object or outcomes are sufficient to motivate interest and participation, members of the SL community move beyond providing customer/client roles (motivating the development of goods by others) and instead they become subjects. The SL community provides both instrumental and psychological value, embodying a project’s accumulated inventory of knowledge, beliefs, values, behaviors, meanings, ideas, labor, user created tools, textures, scripts, design concepts, etc. These are expressed and exposed in a dynamic virtual manner both within the VW as well as through traditional community support platforms such as forums and wikis. However, participation in communities creates additional tensions and problems, including the need to reconcile individual interests and motivations with the larger community, and the effective governance of such communities. Thus we call for future researchers to investigate both the nature of communities in VWs, and the salient affordances provided by VW technologies for sustaining and governing communities.

Second, our study highlights that SL does not provide users with traditional shared design iteration tools to utilize throughout a development project. However users are able to create virtual goods within their own development environment, including tools that facilitating idiosyncratic collaborative and development practices. This highlights the ability for the platform to transcend its in-built capabilities, not alone through upgrades via the provider, but also through the development of innovative tools by users. Thus we call for future researchers to investigate the conception, development, use and diffusion of such tools and other forms of user innovation that facilitate collaborative development.

Third, this study reveals the importance of artifact sharing within collaborative development communities in VWs. Sharing includes transferring of goods between users, as well as making them accessible for others to use/manipulate. These acts of sharing are governed by digitally enforced permission settings, enforcing collaborating users to explicitly manage the intellectual property settings of their virtual goods. In addition, and particularly applicable to organizations, the sharing of accounts is understood to provide an efficient, flexible and convenient manner in which users can overcome ownership and transfer issues associated with virtual goods ranging from the management of 3D models to virtual land (the development workspace). Thus we call for future researchers to more deeply investigate the role of shared objects, and sharing practices, in collaborative development activities in VWs.

Fourth, this study provides a theoretical scaffolding for future analytical work examining collaborative development activities within VWs. AT as used here, focused predominately on activities within the VW, however we call for further studies examining co-located collaborating users, which may expand upon our work by examining interactions between the ‘real’ and ‘virtual’ worlds. Detailed analysis, explicitly capturing activity in virtual as well as physical contexts inclusively within other open-cultural VWs (e.g. OpenSim) may also reveal alternative insights into VW collaborative development activities.

Finally, collaborative development in VWs includes a range of activities beyond those detailed in this study, which focused on developing large artifacts such as buildings and places. Alternative development activities include the creation of ‘clothing’, ‘scripts’ and ‘avatar gestures’ by groups of users. Further studies focusing on these alternative strands of VW collaborative development are needed in order to fully understand the nature of collaboration and development within VWs.



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